Fermilab FERMILAB-Conf-00/307-E CDF December 2000

CHARMED MESON AND ONIUM PRODUCTION AT THE TEVATRON

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We report recent results of $D^{*\pm}$ meson, J/ψ and Υ production at the Fermilab Tevatron. We observe about 8000 $D^{*\pm}$ mesons reconstructed in the decay chain of $D^* \to D^0\pi, D^0 \to K\mu{+}X$. We measure the integrated D^{*+} production cross section to be $347 \pm 65(\text{stat.}) \pm 58(\text{sys.})$ nb for the rapidity range $|\eta(D^{*+})| < 1.0$ and the transverse momentum range $p_T(D^{*+}) > 10$ GeV/c. The measurement is slightly higher than the theoretical prediction, especially at lower p_T range. We also measure the polarization of J/ψ at production and find that the measured transverse polarization is not well explained by the color-octet model proposed to explain the anomalously high J/ψ production cross section. We also present a new result on Υ production and polarization. Production of the Υ is consistent with being unpolarized.

1 Measurement of the D^{*+} Cross Section

The charmed meson production cross section gives complementary information on high energy heavy quark production mechanisms to the previously measured b-quark cross sections. In this paper, we present the first measurement of charmed meson production in $p\overline{p}$ collisions at $\sqrt{s} = 1.8$ TeV.

A $D^{*\pm}$ meson is reconstructed through the decay chain $D^* \to D^0\pi, D^0 \to K\mu + X$, where we triggered the event on a muon of p_T greater than 7.5 GeV/c. The $D^{*\pm}$ meson signature is the small mass difference between the $D^{*\pm}$ meson and the daughter D^0 meson. In this analysis, we identify the $D^{*\pm}$ events from the mass difference between (K, μ, π) and (K, μ). We denote ΔM as this mass difference hereafter. In Figure 1, we show the ΔM distributions for events with the right-sign combination (RS) and events with the wrong-sign combination (WS). The RS represents a combination of $\mu^\pm K^\mp \pi^\pm$, and the WS is $\mu^\pm K^\mp \pi^\mp$. In Figure 1, we observe a clear peak for $D^{*\pm}$ events in RS. The ΔM distribution for WS is used to estimate the background distribution. We

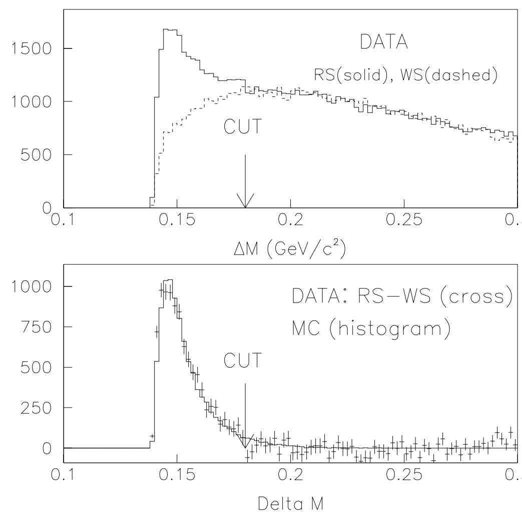

Figure 1: The ΔM distribution. In the top plot, we show both the RS events and the WS events. In the bottom, we show the distribution of RS minus WS with the Monte Carlo (MC) expectation.

study the origin of the $D^{*\pm}$ events by measuring their proper decay-time distribution. We find that direct charm quark production is reponsible for 98 ± 2 % of the $D^{*\pm}$ events. We use the p_T distribution of the (K, μ, π) system to measure the differential cross section for $D^{*\pm}$ production. In Table 1, we show the final result for the D^{*+} meson cross section. The differential and integral cross sections are also shown in Figure 2. We find that the measured cross section is higher than the theoretical prediction, especially at lower p_T range.

Table 1: The differential and integrated cross sections for D^{*+} production. $< p_T >$ is the average p_T in the p_T bin, and p_T^{min} is the lowest p_T in the bin. The first error is statistical and the second is systematic.

$p_T(D^{*\pm})$	$< p_T >$	$d\sigma/dp_T$ (nb/(GeV/c))	$\sigma(p_T > p_T^{min})$ (nb)
10.0 - 12.5	11.0	$79 \pm 28 \pm 13$	$347 \pm 65 \pm 58$
12.5 - 15.0	13.6	$31.6 \pm 7.5 \pm 5.3$	$149 \pm 18 \pm 25$
15.0 - 17.5	16.1	$15.2 \pm 2.8 \pm 2.6$	$70.0 \pm 6.8 \pm 11.8$
17.5 - 20.0	18.6	$6.4 \pm 1.3 \pm 1.1$	$32.1 \pm 3.1 \pm 5.4$
20.0 - 25.0	22.0	$2.3 \pm 0.3 \pm 0.4$	$16.2 \pm 1.5 \pm 2.7$
25.0 - 30.0	27.0	$0.59 \pm 0.15 \pm 0.10$	$4.5 \pm 0.7 \pm 0.8$
30.0 - 35.0	32.1	$0.19 \pm 0.08 \pm 0.03$	$1.6 \pm 0.5 \pm 0.3$
35.0 - 40.0	37.1	$0.086 \pm 0.038 \pm 0.014$	$0.61 \pm 0.18 \pm 0.10$
40.0 - 50.0	43.7	$0.019 \pm 0.006 \pm 0.003$	$0.19 \pm 0.06 \pm 0.03$

2 J/ψ Polarization

In a previous CDF analysis [1], the J/ψ production cross section was found to be "anomalously" high by a factor of 50 compared with the usual color-singlet production model [2]. A possible explanation in terms of color-octet production was then proposed [3]. A consequence of this model is the transverse polarization of J/ψ's produced at high p_T.

We select $J/\psi \to \mu^+\mu^-$ event for this analysis. The proper decay length, ct, is used to separate the promptly produced component from the component coming from B decay. The polarization of the prompt component (α^P) and of the B-decay contribution (α^B) are shown in Figure 3 as a function of $p_T^{J/\psi}$. The error bars include estimates of the systematic errors, which

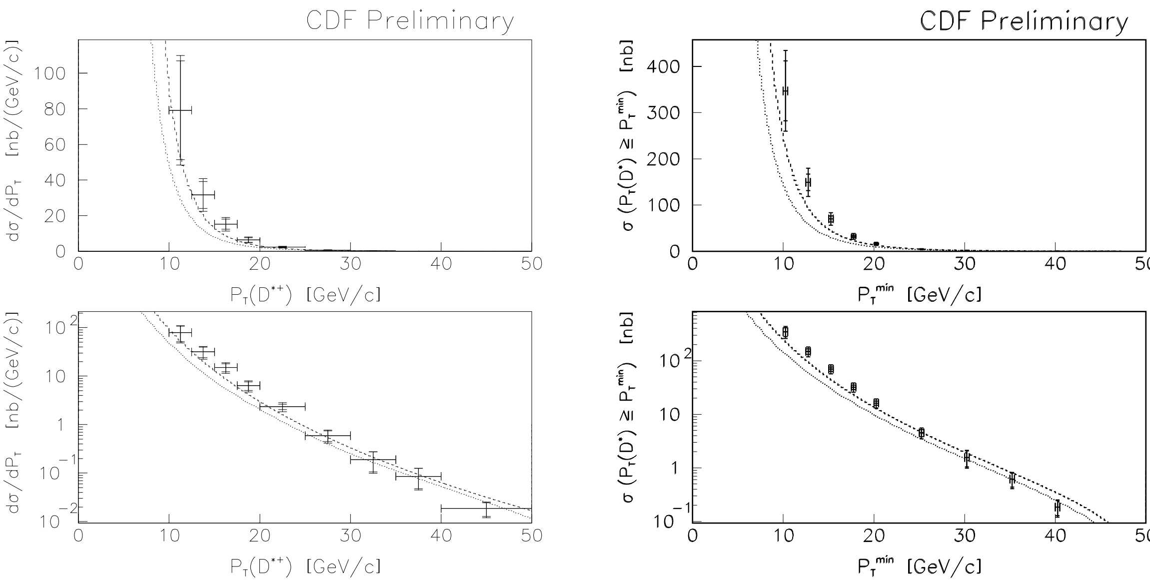

Figure 2: The differential and integrated cross sections for D^{*+} production in $p\overline{p}$ collisions at $\sqrt{s}$ = 1.8 TeV. We show the theoretical prediction provided by Matteo Cacciari (dashed line). We also show another calculation (dotted line) by M. Mangano *et al.*, with a Peterson fragmentation function of $\epsilon = 0.078$, a charm quark mass of 1.5 GeV/c and $\mu^2 = (p_T^2 + m_c^2)$. The inner error bars show the statistical error and the outer error bars show the sum of the statistical and systematic errors.

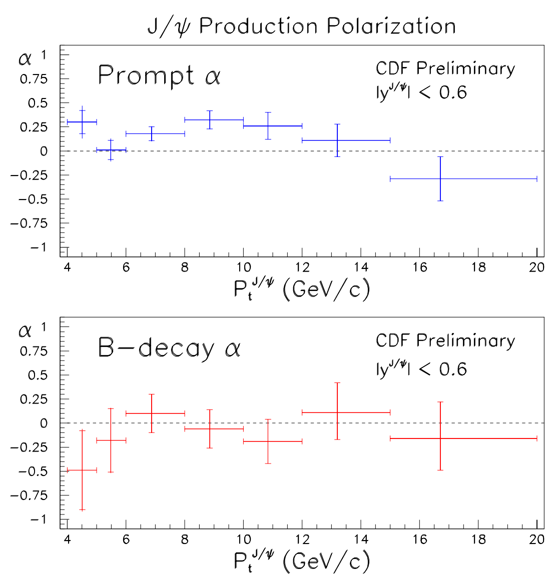

Figure 3: J/ψ polarizations for the prompt and B decay components in the $p_T^{J/\psi}$ range 4 to 20 GeV/c.

in general are small compared with statistical errors. The prompt polarization α^P is seen to rise above $p_T^{J/\psi} = 6$ GeV/c but then fall, so that it is consistent with zero at high $p_T^{J/\psi}$. The value of α^B is consistent with zero over the full $p_T^{J/\psi}$ range. It should be noted here that the fraction of directly produced J/ψ's in the prompt sample is approximately 64 %, with the rest coming from the decay of χ_c and $\psi(2S)$. This result does not support predictions of predominantly transverse polarization given in reference [4].

3 Υ Production and Polarization

CDF has previously published results on Υ production based on 16.6 pb^{-1} of dimuon triggers [5]. In this paper, we present a new result on the cross section and a polarization analysis similar to that for the J/ψ, but without the complication of separating the prompt component from B decay. The production cross section for $\Upsilon(1S)$ is shown in Figure 4. The error bars represent the statistical and systematic errors.

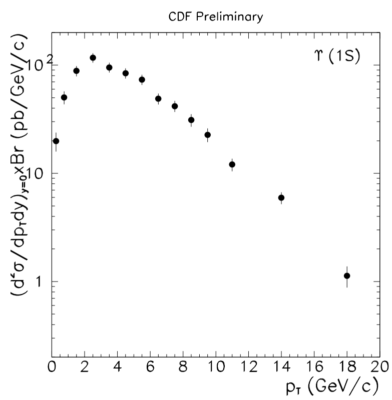

Figure 4: The differential cross section times $Br(\Upsilon \to \mu^+\mu^-)$ for $\Upsilon(1S)$ production.

We also measure the Υ polarization. The longitudinal fraction Γ_L/Γ is measured to be (0.37±0.04), which corresponds to the usual polarization parameter $\alpha = -0.08 \pm 0.09$. Restricting the p_T^{Υ} to be in the range $8 < p_T^{\Upsilon} < 20$ GeV/c yields a value of $\Gamma_L/\Gamma = 0.32 \pm 0.11$ ($\alpha = 0.03 \pm 0.25$). Hence Υ is also produced unpolarized at the higher values of p_T^{Υ}. This result probably does not contradict the predictions of the color-octet model because transverse polarization is only expected to be large when $p_T^2 \gg m_q^2$, where m_q in this case is the b quark mass [4].

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